NOTE ON THE DINOSAUR-TURTLE ANALOGY

IN my paper, "Notes on the Armored Dinosauria,"[1] I first gave general form to the idea that there is a distinct structural parallel between the armor of turtles and Dinosaurs, but that while in the former fixity and regularity of pattern were early developed, in the latter bizarre patterns were assumed. The main thought was also mentioned in a brief earlier paper of March, 1909, in the same *Journal*.

But this view can be made much clearer now. Both Hay and later Von Huene[2] agree in pointing out that the so-called parietal extensions of *Triceratops* are in reality projections formed by the fusion of elements which should be called *dermo-parietals*. I go further and state that this is not only correct, but that in all probability there are two additional lateral dermal elements fused with the squamosals, hypothetically the *dermo-squamosals;* and the hypothesist is clearly at liberty to go on and say that the horns as well may include equivalent dermo-cornutal elements. Now any such dermo-cornutal region may, and both the dermo-parietal and dermo-squamosal region must belong to the same deep dermogene layer in the Ceratopsidæ that in *Polacanthus* and all the Nodosauridæ gives rise to what I descriptively call the lumbar-hip-carapace which clearly results from the fusion of dermo-iliac plates. For in all these instances, whether in the skull region of the Ceratopsids, or the post-dorsal region of *Polacanthus,* we see the bones of this primary deep dermal layer undergoing direct fusion with the endoskeleton, just as in the dorsum of the turtles. Moreover, just as I proved in the case of the early turtles like *Archelon* and *Toxochelys Bauri,* the bones of this deep layer bear or are ridden by those of an outer superficial layer. The demonstration of this superficial layer and its *run in keels* of course explained the origin of the osteodermal carapace of *Dermochelys.*

Homologously the outer osteodermal layer is represented in the Ceratopsids by the *epoccipitals,* as Marsh called them, which *ride* the dermo-parietal and dermo-squamosal region and by the similar usually keeled series of various Dinosaurs. Only in *Stegosaurus* is it difficult to state whether the two huge rows of dorsal spines belong to the outer, or to the nether dermogene armor-producing layer; while it is not absurd to suggest that the dorsal plates could possibly result from the fusion of elements of both layers. Though we should not lose sight of the alternative explanation that the skull plates of *Ankylosaurus,* the horns and frill of *Triceratops,* the dorsal plates of *Stegosaurus* and the dermo-iliac elements of *Polacanthus, Nodosaurus* and *Stegopelta* may all be homologous elements of a dominant midline armor arising from the deep dermogene layer and thus in part analogous to the pleuralia of turtles.

Similarly, going much further afield, it is entirely possible that in the origin of the extraordinary supra-occipital crest of *Pteranodon* brought to light in the course of the admirable studies of Eaton, some strictly dermal element has played a part. And, indeed, responsive or counter growth of the endoskeleton finally resulting in fusion with dermogene elements and the complete obliteration of sutural lines, is of common observation in the Vertebrata, being essentially a senile course of development, which has to do with the aging of races quite as much as the production of purely protective features. The studies of Beecher on the origin of spines have interest in this connection.

Going back to the first premise: As noted, in strong contrast to crocodile-like reptilian types with an outer dermogene bone-producing layer only, the turtles originally had prominently developed, both the outer and nether dermogene layers. But they early tended to strengthen and use the under layer only along very conservative lines, and in their history never developed cranial armature, save in the comparatively recent and altogether aberrant *Meiolania.* On the contrary, as fusion of the dermogene with the chondrogene elements of the carapace and plastron went on, the armorless head became more or less retractile; while the carapace and plastron, though of

[1] *American Journal of Science,* February, 1911.

[2] *Neues Jahrbuch,* Jahrg. 1911, p. 146, 1912.

virtually senile origin, have plainly been the primary factor in giving to the Testudinata an exceedingly long lease of life.

Appositely, in the Dinosauria, a far more active and aggressive race, strong development of both body and cranial armature, in both the upper and the nether dermogene layers, largely confines itself to the bizarre patterns of Cretaceous times. Thus, it is plainly the under layer which gives rise to the huge plate roofing the entire skull in the remarkable genus *Ankylosaurus* of Brown. In the Ceratopsids, as stated, the outer dermogene layer forms the epoccipital fringe of the under stratum, which is not, as at first supposed, an excrescent skull growth, but deep dermal bone in reality strictly homologous to the hip armature of *Polacanthus*. Considered separately, we can reach but indefinite surmises as to the mode of origin or the meaning of these armor features. But clearly, when taken in their complementary relation, unity is restored to the armored series, and the simple structure generalization which clears up its true nature is at once discerned.

In a word, then, the Dinosaurs, instead of eventually confining extensive dermal development to a single nether layer covering the body region only, as in the turtles, tended to develop both the nether and outer layers in the body or skull or both. And this is only another but definite way of saying that the dermal armature was variously developed in the Dinosauria, or that it tended to assume bizarre patterns, whether we consider the final results as devices for offense or defense, or a primary or secondary use of dermal ossifications of essentially senile nature or origin. In either case, in strong contrast to the conservative armor development seen in the turtles, this growth of the most formidable armature known in land animals must have resulted in a most delicately balanced environmental adjustment in the entire race of armored Dinosaurs.

Obviously, too, this conception of the Dinosaurian armor as arising from the two dermogene bone-forming layers is still further simplified on observing the constant tendency of the separate plates or elements to develop nodes of growth which could arise anywhere on their surfaces or borders, in series forming the most ornate patterns. The plate, or flat dermal element, thus lifts itself up by the simplest process into the great frill of *Triceratops,* the tremendous erect flat plates of *Stegosaurus,* or the huge caudal spines of the latter animal or of *Nodosaurus* or those of *Hierosaurus.* Furthermore, the development of the supracranial horn-cores in *Triceratops* can, whatever their origin, offer no difficulty to the parallel between Dinosaurian and Testudinate armature here drawn, since these features are at least morphologically repeated in *Meiolania.* In both these cases, too, the horns may be viewed as exceptional structures quite apart from the dermal growth and modifications characteristic of turtles, and now known to have been present in an immensely varied and cosmopolitan series of Dinosaurians. The summation we therefore fairly reach is that the growth impulse in the dermogene layers which forms *the* pre- or *dermo-dentary* diagnostic of the Predentata, culminates in the *rostral, dermocornutal* and *frill* investiture of the Ceratopsids; while the dorsal armor of the Stegosaurs, and the cranio-dorsal armature of the Nodosaurids are all structurally homologous—it being in most cases plain to which of the two dermogene bone-producing layers any given element belongs, just as in the Testudinata.

In closing, I may be allowed to assert that this exceedingly simple explanation of the Dinosaurian armor at once gives us a clearer conception of the relationships of the various Dinosaur groups, and invites renewed study for the purpose of determining what endoskeletal variations resulted secondarily to the development of the dermal armor. It encourages us to believe, moreover, that the day can not be far distant when some of the proximate causes of armor development may be discerned, now that we see that armored Dinosaurs are by no means so strangely or fundamentally different from other Dinosaurs or even from other reptiles, as was once supposed.

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